AMENDMENTS TO THE CLAIMS

Please amend the claims by amending claim 121, without prejudice, as indicated on the following listing of all the claims in the present application after this Amendment:

1. (Original) An optical method for measuring characteristics of a sample, comprising:

illuminating a surface of the sample by a beam of radiation along an illumination path , radiation in said beam comprising at least one wavelength component in a vacuum ultraviolet (VUV) range;

detecting radiation from the surface originating from the beam along a detection path to provide at least one output signal;

reducing amount of ambient absorbing gases and moisture present in at least a portion of each of the illumination and detection paths by displacing said gases and moisture with another gas that does not substantially absorb the at least one VUV wavelength component so as to reduce attenuation of the at least one VUV wavelength component; and

determining the characteristics of the surface from said at least one output signal.

2. (Original) The method of claim 1, wherein said determining determines information related to metrology of the sample.

3. (Original) The method of claim 2, wherein said information is related to reflectivity, film thickness, index of refraction, and/or grating parameters of the sample.

4. (Original) The method of claim 3, wherein said grating parameters of the sample comprise critical dimension, wall angle, pitch, height and/or profile of gratings.

5. (Original) The method of claim 1, wherein radiation in the beam is polarized.

6. (Original) The method of claim 5, further comprising causing polarization of detected radiation from the beam to vary with time.

7. (Original) The method of claim 6, said causing comprising rotating a polarizer or compensator in the illumination and/or detection paths.

8. (Original) The method of claim 6, wherein said information is related to reflectivity, film thickness, index of refraction, and/or grating parameters of the sample, and/or change of phase of the radiation in the beam caused by the sample.

9. (Original) The method of claim 6, wherein said rotating rotates a polarizer, said method further comprising comparing phase shifts caused by the sample in the output signal to two orthogonally polarized radiation components in the detected radiation to find a reference for measurement.

10. (Original) The method of claim 1, wherein said determining determines information related to an ellipsometric parameter of the sample.

11. (Original) The method of claim 10, wherein said illuminating comprises selecting an angle of incidence of the beam at a surface of the sample to increase sensitivity of detection of said ellipsometric parameter.

12. (Original) The method of claim 11, wherein said sample comprises a silicon nitride layer, and said selecting selects an angle of incidence of the beam at a surface of the sample to increase sensitivity of detection of said ellipsometric parameter of said silicon nitride layer.

13. (Original) The method of claim 10, wherein said information is related to reflectivity, film thickness, index of refraction, and/or grating parameters of the sample, and/or change of phase of the radiation in the beam caused by the sample.

14. (Original) The method of claim 1, wherein said illuminating comprises varying an angle of incidence of the beam at a surface of the sample and said detecting detects radiation from the surface at a corresponding angle.

15. (Original) The method of claim 14, wherein said information is related to reflectivity, film thickness, index of refraction, and/or grating parameters of the sample, and/or change of phase of the radiation in the beam caused by the sample.

16. (Original) The method of claim 1, wherein said illuminating comprises illuminating the surface at different angles of incidence substantially simultaneously and said detecting detects radiation from the surface along detection paths at different elevation angles from the surface substantially simultaneously.

17. (Original) The method of claim 16, wherein said information is related to reflectivity, film thickness, index of refraction, and/or grating parameters of the sample, and/or change of phase of the radiation in the beam caused by the sample.

18. (Original) The method of claim 1, wherein said illuminating comprises illuminating the surface at different azimuthal angles substantially simultaneously and said detecting detects radiation from the surface along detection paths at different azimuthal angles from the surface substantially simultaneously.

19. (Original) The method of claim 18, wherein said information is related to reflectivity, film thickness, index of refraction, and/or grating parameters of the sample , and/or change of phase of the radiation in the beam caused by the sample.

20. (Original) The method of claim 1, wherein said illuminating comprises illuminating the surface with radiation of multiple wavelength components and said detecting detects ellipsometric parameters of the sample.

21. (Original) The method of claim 20, wherein said information is related to reflectivity, film thickness, index of refraction, and/or grating parameters of the sample, and/or change of phase of the radiation in the beam caused by the sample.

22. (Original) The method of claim 20, wherein said multiple wavelengths are in the visible, UV, DUV, VUV and/or IR ranges.

23. (Original) The method of claim 20, wherein said multiple wavelength components comprise broadband radiation.

24. (Original) The method of claim 1, wherein said illuminating comprises focusing the beam to an area on a surface of the sample, said area having a dimension not more than about 200 microns.

25. (Original) The method of claim 1, wherein said illuminating comprises supplying broadband radiation to illuminate the sample.

26. (Original) The method of claim 25, wherein said broadband radiation comprises wavelength components in a range of about 100 to 1200 nm.

27. (Original) The method of claim 1, wherein said determining determines information related to anomalies on or near a surface of the sample.

28. (Original) The method of claim 27, wherein said detecting detects radiation in a bright field, dark field and/or double dark field arrangement.

29. (Original) The method of claim 27, further comprising causing the surface to be scanned by a beam of radiation.

30. (Original) The method of claim 27, further comprising causing the surface to be scanned by a beam of radiation when radiation from the beam is detected to determine information related to anomalies on or near an area of the surface of the sample.

31. (Original) The method of claim 30, wherein said causing causes the beam to scan a serpentine or spiral path on the surface.

32. (Original) The method of claim 30, wherein said causing causes the surface to be moved without moving the illumination and detection paths.

33. (Original) The method of claim 27, wherein said detecting detects, separately and by means of different detection channels, radiation from the beam scattered by the surface in different directions that are arranged substantially symmetrically about a line normal to the surface.

34. (Original) The method of claim 27, wherein said beam is at an oblique angle to the surface of the sample, and wherein said detecting detects, separately and by means of different detection channels, radiation from the beam scattered by the surface within different ranges of azimuthal angles relative to the beam.

35. (Original) The method of claim 27, further comprising collecting radiation from the beam and scattered in different directions from the surface by means of a collector that is substantially symmetrical about a line normal to the surface.

36. (Original) The method of claim 27, wherein said detecting detects, separately and by means of different detection channels, radiation from the beam scattered by the surface in different directions that are at different elevation angles from the surface.

37. (Original) The method of claim 27, wherein said detecting detects separately two or more of the following: forward scattered radiation, back scattered radiation and radiation scattered in a direction normal to the surface.

38. (Original) The method of claim 27, wherein said illuminating comprises directing said beam at a normal direction to the surface of the sample.

39. (Original) The method of claim 27, wherein said illuminating comprises directing said beam at an oblique direction to the surface of the sample.

40. (Original) The method of claim 1, wherein said reducing comprises directing a stream of gas to said at least a portion of each of the illumination and detection paths.

41. (Original) The method of claim 40, wherein said directing directs the stream of gas from a source of the gas that contains substantially no absorbing gas and moisture.

42. (Original) The method of claim 41, wherein said directing directs the stream of gas from a source of nitrogen or an inert gas.

43. (Original) The method of claim 40, wherein said directing directs the stream of gas towards a measurement area on the surface illuminated by the beam.

44. (Original) The method of claim 43, wherein said directing is such that laminar flow of the gas at or near the measurement area is enhanced.

45. (Original) The method of claim 43, wherein said directing is such that at least some contaminants and moisture at or near the measurement area on the surface are removed.

46. (Original) The method of claim 43, wherein said directing is such that turbulent flow of the gas at or near the measurement area is reduced.

47. (Original) The method of claim 1, wherein said reducing comprises enclosing in an envelope of at least a portion of each of the illumination and detection paths in a gas that contains less oxygen and moisture than those in an atmosphere surrounding said envelope.

48. (Original) The method of claim 47, wherein said illuminating illuminates a measurement area on the surface, said method further comprising maintaining said envelope at a pressure higher than that at a portion of each of the illumination and detection paths outside the envelope and near the measurement area on the surface.

49. (Original) The method of claim 47, wherein said illuminating illuminates a measurement area on the surface, said envelope defining an opening, the illumination and detection paths passing through the opening, said reducing further comprising directing a stream of gas from the envelope through the opening towards the measurement area on the surface.

50. (Original) The method of claim 49, further comprising causing the opening to be within 1 cm from the surface.

51. (Original) The method of claim 47, wherein said sample is outside of the envelope during the illuminating, collecting, reducing and detecting.

52. (Original) The method of claim 1, wherein said reducing reduces the amount of ambient absorbing gases and moisture without placing the sample in a vacuum.

53. (Original) A optical apparatus for measuring characteristics of a sample, comprising:

optics illuminating a surface of the sample by a beam of radiation along an illumination path, radiation in said beam comprising at least one wavelength component in a vacuum ultraviolet range;

a detector detecting radiation from the surface originating from the beam along a detection path to provide at least one output signal;

an instrument reducing amount of ambient absorbing gases and moisture present in at least a portion of each of the illumination and detection paths by displacing said gases and moisture with another different gas so as to reduce attenuation of the at least one wavelength component; and

means for determining the characteristics of the surface from said at least one output signal.

54. (Original) The apparatus of claim 53, wherein said determining means determines information related to metrology of the sample.

55. (Original) The apparatus of claim 54, wherein said information is related to reflectivity, film thickness, index of refraction, and/or grating parameters of the sample, and/or change of phase of the radiation in the beam caused by the sample.

56. (Original) The apparatus of claim 55, wherein said grating parameters of the sample comprise critical dimension, wall angle, pitch, height and/or profile of gratings.

57. (Original) The apparatus of claim 53, wherein radiation in the beam is polarized.

58. (Original) The apparatus of claim 57, further comprising a device rotating a polarizer or compensator in the illumination and/or detection paths.

59. (Original) The apparatus of claim 58, wherein said information is related to reflectivity, film thickness, index of refraction, and/or grating parameters of the sample, and/or change of phase of the radiation in the beam caused by the sample.

60. The apparatus of claim 58, wherein said device rotates a polarizer, said determining means comparing phase shifts caused by the sample in the output signal to two orthogonally polarized radiation components in the detected radiation to find a reference for measurement.

61. (Original) The apparatus of claim 53, wherein said determining means determines information related to an ellipsometric parameter of the sample.

62. (Original) The apparatus of claim 61, wherein said optics comprises a device selecting an angle of incidence of the beam at the surface of the sample to increase sensitivity of detection of said ellipsometric parameter.

63. (Original) The apparatus of claim 62, wherein said sample comprises a silicon nitride layer, and said device selects an angle of incidence of the beam at the surface of the sample to increase sensitivity of detection of said ellipsometric parameter of said silicon nitride layer.

64. (Original) The apparatus of claim 61, wherein said information is related to reflectivity, film thickness, index of refraction, and/or grating parameters of the sample, and/or change of phase of the radiation in the beam caused by the sample.

65. (Original) The apparatus of claim 53, wherein said optics varies an angle of incidence of the beam at a surface of the sample and said detector detects radiation from the surface at a corresponding angle.

66. (Original) The apparatus of claim 65, wherein said information is related to reflectivity, film thickness, index of refraction, and/or grating parameters of the sample, and/or change of phase of the radiation in the beam caused by the sample.

67. (Original) The apparatus of claim 53, said optics illuminating the surface at different angles of incidence substantially simultaneously and said detector detects radiation from the surface along detection paths at different elevation angles from the surface substantially simultaneously.

68. (Original) The apparatus of claim 67, wherein said information is related to reflectivity, film thickness, index of refraction, and/or grating parameters of the sample, and/or change of phase of the radiation in the beam caused by the sample.

69. (Original) The apparatus of claim 53, said optics illuminating the surface at different azimuthal angles substantially simultaneously and said detector detects radiation from the surface along detection paths at different azimuthal angles from the surface substantially simultaneously.

70. (Original) The apparatus of claim 69, wherein said information is related to reflectivity, film thickness, index of refraction, and/or grating parameters of the sample , and/or change of phase of the radiation in the beam caused by the sample.

71. (Original) The apparatus of claim 53, said optics illuminating the surface with radiation of multiple wavelength components and the detector detects ellipsometric parameters of the sample.

72. (Original) The apparatus of claim 54, wherein said information is related to reflectivity, film thickness, index of refraction, and/or grating parameters of the sample, and/or change of phase of the radiation in the beam caused by the sample.

73. (Original) The apparatus of claim 71, wherein said multiple wavelengths are in the visible, UV, DUV, VUV and/or IR ranges.

74. (Original) The apparatus of claim 71, wherein said multiple wavelength components comprise broadband radiation.

75. (Original) The apparatus of claim 53, wherein said optics comprises an objective focusing the beam to an area on the surface of the sample, said area having a dimension not more than about 200 microns.

76. (Original) The apparatus of claim 53, said optics supplying broadband radiation to illuminate the sample.

77. (Original) The apparatus of claim 76, wherein said broadband radiation comprises wavelength components in a range of about 100 to 1200 nm.

78. (Original) The apparatus of claim 53, wherein said determining means determines information related to anomalies on or near the surface of the sample.

79. (Original) The apparatus of claim 78, wherein said detector detects radiation in a bright field, dark field and/or double dark field arrangement.

80. (Original) The apparatus of claim 78, further comprising a device causing the surface to be scanned by a beam of radiation.

81. (Original) The apparatus of claim 78, said device causing the surface to be scanned by a beam of radiation when radiation from the beam is detected to determine information related to anomalies on or near an area of the surface of the sample.

82. (Original) The apparatus of claim 81, wherein said device causes the beam to scan a serpentine or spiral path on the surface.

83. (Original) The apparatus of claim 81, wherein said device causes the surface to be moved without moving the optics and detector.

84. (Original) The apparatus of claim 78, wherein said detector comprises different detection channels, said detector comprising a plurality of detection channels detecting separately radiation from the beam scattered by the surface in different directions that are substantially symmetrically about a line normal to the surface.

85. (Original) The apparatus of claim 78, wherein said beam is at an oblique angle to the surface of the sample, said detector comprising a plurality of detection channels detecting separately radiation from the beam scattered by the surface within different ranges of azimuthal angles relative to the beam.

86. (Original) The apparatus of claim 78, further comprising a collector that is substantially symmetrical about a line normal to the surface collecting radiation from the beam and scattered in different directions from the surface, wherein the detector detects the radiation that is collected by the detector.

87. (Original) The apparatus of claim 78, wherein said detector comprises different detection channels, said detector comprising a plurality of detection channels detecting separately radiation from the beam scattered by the surface in different directions that are at different elevation angles from the surface.

88. (Original) The apparatus of claim 78, said detector comprising a plurality of detection channels detecting separately two or more of the following: forward scattered radiation, back scattered radiation and radiation scattered in a direction normal to the surface.

89. (Original) The apparatus of claim 78, said optics directing said beam at a normal direction to the surface of the sample.

90. (Original) The apparatus of claim 78, said optics directing said beam at an oblique direction to the surface of the sample.

91. (Original) The apparatus of claim 53, said instrument directing a stream of gas to said at least a portion of each of the illumination and detection paths.

92. (Original) The apparatus of claim 91, wherein said instrument directs the stream of gas from a source of the gas that contains substantially no absorbing gas and moisture.

93. (Original) The apparatus of claim 92, wherein said instrument directs the stream of gas from a source of nitrogen or an inert gas.

94. (Original) The apparatus of claim 91, wherein said instrument directs the stream of gas towards a measurement area on the surface illuminated by the beam.

95. (Original) The apparatus of claim 94, wherein said instrument causes laminar flow of the gas at or near the measurement area to be enhanced.

96. (Original) The apparatus of claim 94, wherein said instrument directs the gas towards the measurement area such that at least some contaminants and moisture at or near the measurement area on the surface are removed.

97. (Original) The apparatus of claim 94, wherein said instrument causes turbulent flow of the gas at or near the measurement area to be reduced.

98. (Original) The apparatus of claim 53, wherein said instrument comprises an envelope enclosing therein of at least a portion of each of the illumination and detection paths in

a gas that contains less oxygen and moisture than those in an atmosphere surrounding said envelope.

99. (Original) The apparatus of claim 98, wherein said illuminating illuminates a measurement area on the surface, and wherein said envelope is at a pressure higher than that at a portion of each of the illumination and detection paths outside the envelope and near the measurement area on the surface.

100. (Original) The apparatus of claim 98, wherein said illuminating illuminates a measurement area on the surface, said envelope defining a hole therein, the illumination and detection paths passing through the hole, said instrument directing a stream of gas from the envelope through the hole towards the measurement area on the surface.

101. (Original) The apparatus of claim 100, the hole being within 1 cm from the surface.

102. (Original) The apparatus of claim 100, the hole having a tapered or funnel shape.

103. (Original) The apparatus of claim 102, the hole having a first and a second end where the first end is closer to the surface and is smaller than the second end.

104. (Original) The apparatus of claim 102, further comprising an objective in the envelope adjacent to the hole for focusing radiation in the illumination and detection paths.

105. (Original) The apparatus of claim 100, the hole having two ends that are larger than a section of the hole between the two ends.

106. (Original) The apparatus of claim 100, the hole having two ends wherein the hole has substantially the same dimension between the two ends.

107. (Original) The apparatus of claim 106, further comprising a tube shaped member in the envelope adjacent to the hole.

108. (Original) The apparatus of claim 100, wherein the hole is elongated in shape to accommodate illumination by the beam at an oblique angle to the surface.

109. (Original) The apparatus of claim 108, wherein the hole is substantially elliptical in shape.

110. (Original) The apparatus of claim 98, wherein said sample is outside of the envelope.

111. (Original) The apparatus of claim 53, wherein said optics comprises reflective optics.

112. (Original) The apparatus of claim 111, wherein said optics comprises at least one substantially spherical mirrored surface.

113. (Original) The apparatus of claim 53, wherein said optics comprises at least one lens comprising calcium fluoride.

114. (Original) The apparatus of claim 53, further comprising a collector that is collecting radiation from the beam and scattered by the surface, wherein the detector detects the radiation that is collected by the detector.

115. (Original) The apparatus of claim 114, wherein said collector comprises reflective optics.

116. (Original) The apparatus of claim 115, wherein said collector comprises at least one substantially paraboloidal or ellipsoidal mirrored surface.

117. (Original) The apparatus of claim 115, wherein said collector comprises at least one substantially ellipsoidal mirrored surface that has an axis that is substantially normal to the surface.

118. (Original) The apparatus of claim 114, wherein said collector comprises a plurality of collection devices arranged in a ring surrounding a portion of the surface illuminated by the beam.

119. (Original) The apparatus of claim 114, wherein said collector comprises at least one lens comprising calcium fluoride.

120. (Original) The apparatus of claim 53, wherein said instrument reduces the amount of ambient absorbing gases and moisture without placing the sample in a vacuum.

121. (Currently Amended) An optical apparatus for measuring characteristics of a sample, comprising:

optics illuminating a surface of the sample by a beam of radiation along an illumination path, radiation in said beam comprising at least one wavelength component in a vacuum ultraviolet range;

a detector detecting radiation from the surface originating from the beam along a detection path to provide at least one output signal;

an instrument reducing amount of ambient absorbing gases and moisture present in at least a portion of each of the illumination and detection paths by displacing said gases and moisture with another different gas so as to reduce attenuation of the at least one wavelength component, said instrument comprising an envelope having an opening and enclosing said optics and detector and containing a gas that contains less oxygen and moisture than those in an

atmosphere surrounding said envelope and that is at a higher pressure than said atmosphere, wherein said amount is reduced by a flow of said different gas in the envelope and said opening;

means for shielding the opening from the atmosphere to enhance laminar flow of the gas through the opening; and

means for determining the characteristics of the surface from said at least one output signal.

122. (Original) The apparatus of claim 121, wherein said shielding means comprises a gas that does not absorb the at least one VUV wavelength component flowing through a space between the sample and the envelope away from the opening.

123. (Original) The apparatus of claim 121, wherein said shielding means comprises an obstruction between the sample and the envelope.

124. (Original) The apparatus of claim 123, wherein said obstruction is adjacent to or in contact with an outside surface of the envelope.

125. (Original) An optical method for measuring characteristics of a sample, comprising:

illuminating a surface of the sample by a beam of radiation along an illumination path , radiation in said beam comprising at least one wavelength component in a vacuum ultraviolet (VUV) range;

detecting radiation from the surface originating from the beam along a detection path to provide at least one output signal;

maintaining within an envelope pressure of a gas so that it is higher than that of an atmosphere surrounding said envelope, said envelope enclosing at least a portion of each of the illumination and detection paths, said gas containing less oxygen and moisture than the atmosphere, so that said gas escapes through an opening of the envelope;

shielding the opening from the atmosphere to enhance laminar flow of the gas through the opening; and

determining the characteristics of the surface from said at least one output signal.

126. (Original) The method of claim 125, wherein said shielding comprises causing a gas that does not absorb the at least one VUV wavelength component to flow through a space between the sample and the envelope away from the opening.

127. (Original) The apparatus of claim 125, wherein said shielding comprises obstructing a space between the sample and the envelope.